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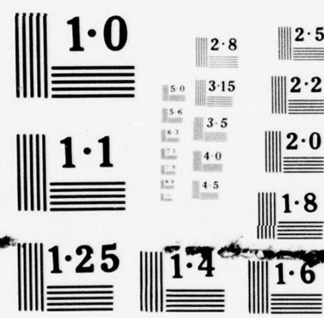
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Current research on reading is hampered by the lack of a framework within which to study the effects of a reader's prior knowledge on his or her processing of an unfamiliar text. As a result, most reading research has emphasized perceptual rather than conceptual processing during reading. Evidence is cited in support of the claim that various types of prior knowledge play important roles in understanding during text processing.

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Recent developments in cognitive psychology and artificial intelligence have resulted in a new kind of model for conceptual processing, called procedural semantics. In this report, a framework is laid for the application of the procedural semantics formalism to the analysis of conceptually-driven processing in reading. According to this theory, two different types of conceptual processing units (called schemata) are responsible for conceptually-driven processing in reading. One type is the form-schema, which accounts for the syntactic or formal expectations which people make use of in text processing. The other type is the content-schema, which accounts for the nature of readers' semantic expectations. Models for a small number of specific form- and content-schemata are proposed, and certain experimental and observational evidence is explained in terms of these models.

Implications for effective strategies for adult reading are derived from the premises of the model. Several different kinds of reading strategies are characterized in terms of the model. When readers employ single-pass strategies, they process the text in a strictly linear, left-to-right fashion. This approach makes minimal use of the potential for conceptually-driven processing that could be achieved through the activation of some high-level schemata. In exhaustive multi-pass processing, the first pass results in the activation of a number of form- and content-schemata which can serve as an aid in subsequent passes, driving expectations about the form and meaning of what is about to be read. This technique can often be wasteful of resources, since it does not actively direct processing toward what is most important or least well understood. Extractive multi-pass processing reflects a more efficient strategy for reading an entire text. By using this technique, a reader "skims" the text in a selective way on repeated passes, building up such a complete understanding of the meaning of the text that the final reading of the text is often a process of merely filling in the gaps in understanding. This technique is often effectively used by graduates of adult reading improvement classes. Selective multi-pass strategies characterize the reading of those who know what it is they want to know, and who are under no constraint to learn all that might be learned from a text. In this type of text processing, the reader begins the task with the intention of acquiring some specific information. As a result, a number of specific content-schemata are activated and are used to guide the order and the selection of those portions of the text to be processed.

Several potential applications are suggested by the consequences of the theory for conceptually-driven processing in reading presented here. These include possible uses for headings in texts, means for constructing advance organizers for texts, and training readers to make more effective use of texts by being sensitive to their motivating tasks and by exploiting their capacities for generating expectations about the meaning of the texts through conceptually-driven processing.

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SUMMARY

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ON COGNITIVE STRATEGIES FOR PROCESSING TEXT

Introduction

We feel a strong need for some kind of model, or theory, of learning from text, to counter the current sterile empiricism in this field, by giving direction to research, and to deal systematically with the characteristics of different kinds of information in the text itself.

Text is a linear string of symbols organized, by spacing, into characters, words, sentences, paragraphs, and higher order subdivisions. A small set of characters can form an enormous number of words, but only a small set of these is used in any one text. Words can be combined to form an infinite number of physically different sentences, but there are only a few commonly used rules for determining sentence structure. Patterns of characters and patterns of words recur over and over in words and in sentences. But, every piece of text is different from every other piece, making it difficult to specify and to control stimulus parameters.

There is little doubt that the familiar patterns of letters in words (Alderman & Smith, 1971), and of words in sentences facilitate text-processing tasks. Familiar structure allows prediction of elements in the structure. Letters of familiar words can be read out of memory after a glance at the printed words. Travers (1973) showed that "...words, or large segments of words, are habitually processed in parallel, while random strings are processed as a series of individual letters or small chunks." (p. 109). The familiar structure of sentences permits prediction of classes of words coming next; nouns, adjectives, verbs, connectives, and the like (see Kolers, 1970; Stevens & Rumelhart, 1975;

Weber, 1970). The readability of the poem "Jabberwocky" is a tribute to the facilitative effect of normal sentence structure, communicated in this case by the presence of particular "function words" (such as prepositions and determiners) and by morphological affixes (such as tense endings, plural markers, and the like). Paragraph structures are much looser, indeed, almost arbitrary in comparision to sentence structures, which, in turn, are more flexible than word structures. Loose though such structures may be, however, readers are sensitive to aberrations in paragraph structures. Meyers & Boldrick (1975), for example, showed that randomly rearranging the order of half of the sentences in a text resulted ina severe deterioration of subjects' abilities to recall the stories later. But, suppose that some sentences were anomalous in terms of meaning; the wrong subjects for the verbs and objects--the locomotive drew a picture of a cow. This introduces semantic "scrambling" without topographic disorder. Marslen-Wilson & Tyler (1976) describe the effects of this treatment on recall. Or, suppose one sentence in the paragraph was not related to the topic of the paragraph. Bransford & Johnson (1973) demonstrated the effects of this kind of semantic scrambling on memory for the information in the paragraph.

We are saying there must be some kind of top-down processing that is predicting detailed levels from higher structure, and that occurs in parallel with the bottom-up processing that synthesizes words from letters, sentences from words, and paragraphs from sentences. Bottom-up processing has been almost exclusively emphasized in theories about reading.

If the levels of text processing tasks--from processing

letters, to processing words, to processing sentences--were combined in appropriate ways with the levels of scrambling text--from letters in words to words in sentences, to sentences in paragraphs, then it is likely that discontinuities would occur in dependent measures that would indicate that at least two sets of processes were running in parallel.

Rumelhart (in press) has advanced an interactive model of reading that describes in some detail mechanisms for interactive top-down/bottom-up processing. Noteworthy are examples he cites of how top-down processing can influence bottom-up processing, his parallel processing mechanisms, and his quantification of the interaction between the two sets of parallel processes as a multiplicative relationship between direct evidence and contextual evidence for hypotheses that drive processing:

$$S_i = V_i \cdot B_i$$

The values of V_i and B_i are determined in terms of mixtures of higher level (parent), same level (right and left sisters) and lower-level (daughter) hypotheses prevailing at any one time.

The following figures from Rumelhart suggest some of the features of his model.

The pattern synthesizer in Figure 1 contains a <u>message center</u> that:

> "Keeps a running list of hypotheses about the nature of the input string. Each knowledge source constantly scans the message center for the appearance of hypotheses relevant to its own sphere of knowledge. Whenever such a hypothesis enters the message center the knowledge source in question evaluates the hypothesis in light of its own specialized knowledge.

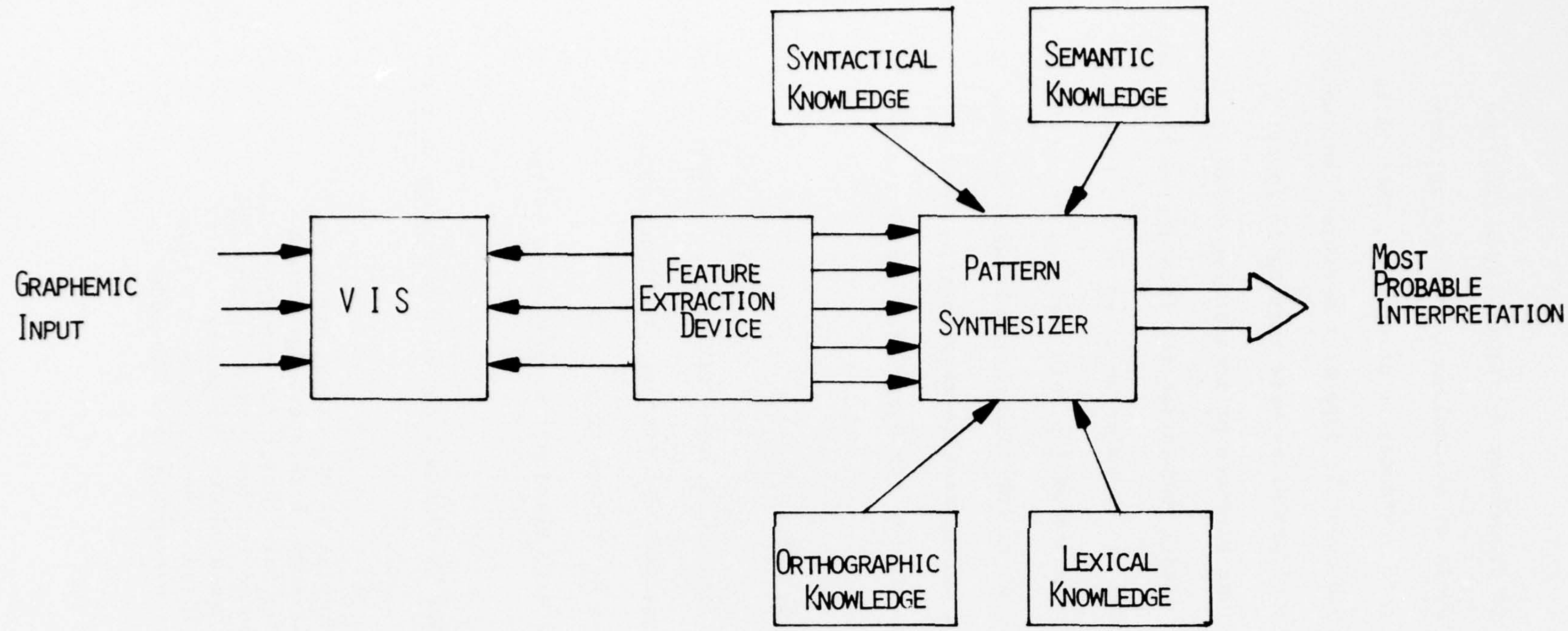

Figure 1.

A stage representation of an interactive model of reading.
(From Rumelhart, in Press)

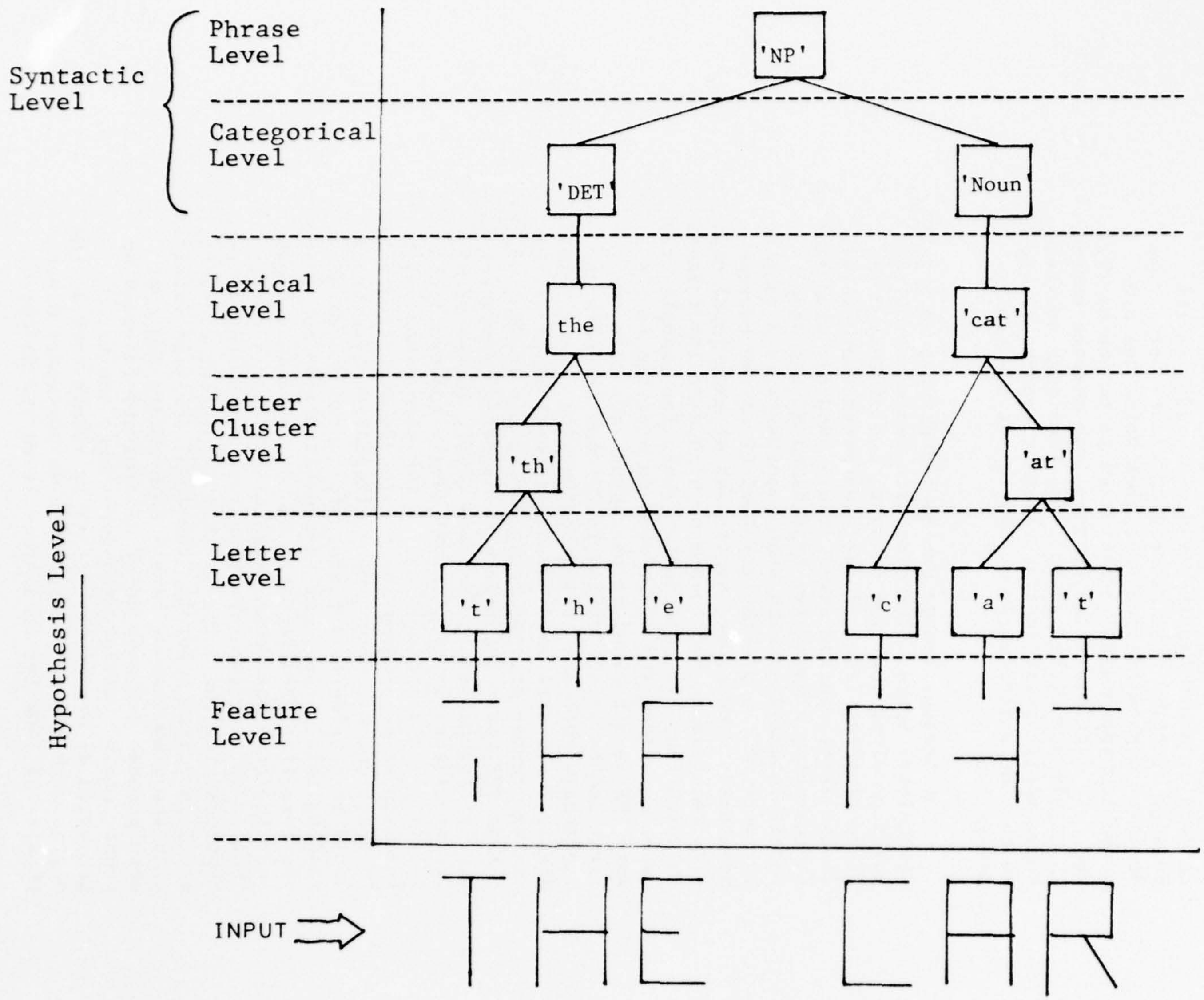

Figure 2.

A two dimensional slice of the message center.
(From Rumelhart, in Press)

As a result of its analysis the hypothesis may be confirmed, disconfirmed and removed from the message center, or a new hypothesis can be added to the message center. This process continues until some decision can be reached. At that point the most probable hypothesis is determined to be the correct one. To facilitate the process, the message center is highly structured so that the knowledge sources know exactly where to find relevant hypotheses and so that dependencies among hypotheses are easily determined.

The message center can be represented as a three-dimensional space. One dimension representing the position along the line of text, one dimension representing the level of the hypothesis (word level, letter level, phrase level, etc.), and one dimension representing alternative hypotheses at the same level. Associated with each hypothesis is a running estimate of the probability that it is the correct hypothesis. Moreover, hypotheses at each level may have pointers to hypotheses at higher or lower levels on which they are dependent. Thus, for example, the hypothesis that the first word in a string is the word THE is supported by the hypothesis that the first letter of the string is 'T' and supports the hypothesis that the string begins with a noun phrase. Figure 2 illustrates a two-dimensional slice of the message center at some point during the reading of the phrase THE CAR. The figure illustrates hypotheses at five different levels (feature level, letter level, letter cluster level, lexical level, and syntactic level). The diagram is only a two-dimensional slice inasmuch as no alternative hypotheses are illustrated. In practice, of course, many alternative hypotheses would be considered and evaluated in the course of reading this phrase. It should be pointed out that the tree-like structure should not be taken to mean that the tree was constructed either from a purely "bottom-up" process (starting with the features, then hypothesizing the letters, then the letter clusters, etc.), nor from a purely "top-down" analysis (starting with the view that we have a noun phrase and that noun phrases are made up of determiners followed by nouns, etc.). Rather, the hypotheses can be generated at any level. If it is likely that a line begins with a noun phrase, then we postulate a noun phrase and look for evidence. If we see features

that suggest a "t" as the first letter we postulate a "t" in the first position and continue processing. If we later have to reject either or both of these hypotheses little is lost. The system makes the best guesses and checks out their implications. If these guesses are wrong it will take a bit longer, but the system will eventually find some hypotheses at some level that it can accept." (Rumelhart, in press)

Schemata in Conceptually-Driven Text-Processing

In his proposal for an interactive model of reading, Rumelhart (in press) makes it clear that there is ordinarily more than one source of conceptually-driven processing during reading. One type of source for top-down analysis is the reader's hypothesis about the general kind of situation or context with which the text deals. A different type of source for top-down processing is the presence of specific "triggers" in the situation or context (as perceived by the reader) which result in more local or specific expectations than those of the first type.

Let us illustrate the difference between these two types of sources for top-down processing by borrowing an extended example of Rumelhart's. If a subject is first shown a picture of a scene (not, let us agree for the present, of an activity), and is then presented with a tachistoscopic exposure of a brief phrase that, according to the instructions, describes some aspect or element of the picture, then two different types of top-down processing are probably brought to bear in the subject's reading of the phrase. The first type of top-down processing is that which has to do with the subject's expectations created by the instructions. That is, the subject understands that the alphabetic string to be presented will have something to do with the scene previously presented; that it will be, in fact, a partial description of that scene. This sort of expectation is very different

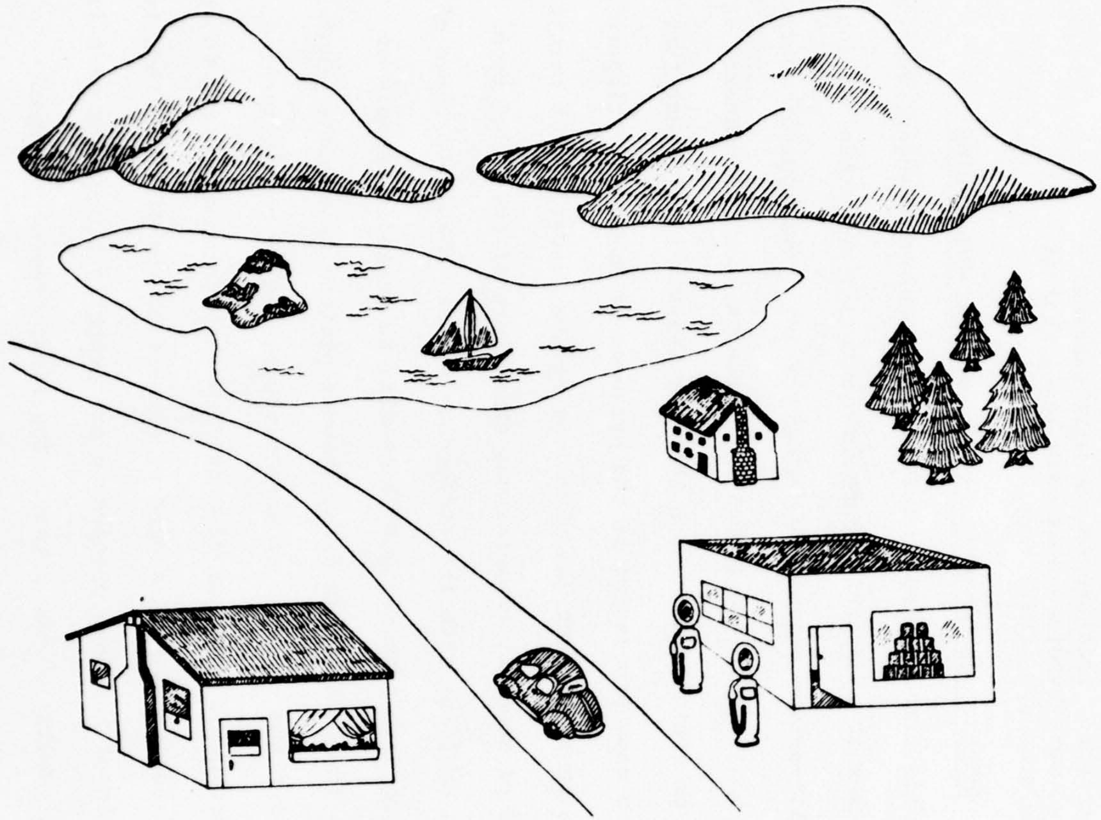

Figure 3.

A scene. Figure provided by Jean Mandler.
(From Rumelhart, in press)

from many others which the subject could have, were the instructions different. With other instructions, for example, the subject might expect to see a phrase which was an explanation of some aspect of the picture. If this were the case, the subject would expect a longer phrase than he does in the case of a partial description, and a phrase with specifically relational or causative predication. Another example of a different sort of expectation which different instructions could arouse is that of a prediction related to some aspect of the picture. In this case, the subject would presumably expect that the phrase would contain some actional or change-of-state predicate.

The second type of top-down or conceptually-driven processing in the context of this experimental example of Rumelhart's is the group of expectations aroused by specific details in the presented scene. Thus, a picture of a Volkswagen parked at a gas station with a lake and mountains in the background (see Figure 3) may be responsible for a series of expectations, such as that the phrase might be "A" Volkswagen," or "A gas station," or "The mountain," or "The lake," and so on. In fact, of course, this is only a small fraction of the possible specific expectations in such a context, since many synonyms or contextually equivalent expressions are possible, such as "The car," "The service station," and so on.

Now, it is all very well to specify that there are at least these two different types of conceptually-driven processing which must be a part of the reading process, but to do this is not at all the same thing as showing how such conceptually-driven processing is actually accomplished. We think that there is a great need for models of specific conceptual/processing entities which are responsible for

these top-down effects. In what follows we sketch an approach to such a model.

A natural framework for the construction of a model of conceptual entities which have both structural and processing aspects is that of procedural semantics (Minsky, 1975; Norman, Rumelhart, & LNR, 1975; Winograd, 1975). Much of what follows is based on a particular procedural semantics model, namely that of the LNR research group.

Above we mentioned two types of conceptually-driven processing which might be expected in the paradigm in which a presentation of a picture is followed by the tachistostopic presentation of an alphabetic string. The effects of the two types of processing can be modeled within a procedural semantics system by two different types of schemata which are activated in this experimental context. The first type of conceptually-driven processing is that which involves expectations or predictions about the form of the string which appears briefly after the picture. This involves a number of fairly explicit predictions about syntax, and a few expectations about portions of the semantic and lexical content of the strings. We propose that the effects of these kinds of expectations be modeled by a type of schema, which, for want of a better name, we will call form-schemata for the present. Examples of form-schemata, explained in greater detail below, include a Description-Schema, an Explanation-Schema, and a Prediction-Schema.

The second type of conceptually-driven processing which should take place in the paradigm of picture-then-phrase involves expectations about the content of the briefly-presented alphabetic strings. This processing can be thought of as a number of fairly explicit expectations

with respect to the semantics and to the lexical components of an utterance. In only a few cases will this type of processing result in syntactic expectations, and those cases will ordinarily involve "idiomatic" expressions, which are themselves much like lexical items. Within a procedural semantics model, the production of these types of expectations can also be modeled, by the actions of another type of schema, the <u>content-schema</u>. Examples of content-schemata, discussed in detail below, include a Service-Station-Schema, a Volkswagon-Schema, a Mountain-Schema, and so on.

In the next two sections, some illustrative examples of form-and-content-schemata are presented.

Form-Schemata

In the experimental context which we have been using as the basis for organizing this discussion, there are a number of possible form-schemata which might be activated, depending on the nature of the instructions given to the subject, as well as on other factors.[1] For the sake of the present discussion, let us assume that there are four possible types of phrases which subjects could be led to expect to see follow the picture. They are <u>descriptions</u>, <u>explanations</u>, <u>predictions</u>, and <u>histories</u>. In the example given in Rumelhart (in press) the sort of phrases used are descriptions.

---

[1] Other factors which might be expected to contribute to the activation of form-schemata must include the subject's previous experience with this experimental paradigm, and the nature of his or her perceptions of the preceding phrase stimuli in the current experimental block. For example, if the instructions informed subjects that they would be presented with partial descriptions of the picture, we would expect the Description-Schema to become activated, and to affect the subject's interpretations of the first phrase presented. If, however, the presented strings were in fact predictions rather than descriptions, then to the extent that subjects correctly manage to perceive the true nature of the presented phrases, their activations of the Description-Schema should be replaced by activations of the Prediction-Schema.

Possible descriptions which could follow a presentation of Figure 1 include "The car," "A service station," "The car is at the service station," "The lake in front of the mountain," and so on. What kind of explanations might follow a presentation of Figure 1? "The car is stopped in the road because it ran out of gas," and so forth. Predictions which could be presented after the subject sees the picture in Figure 1 include "The car will leave soon," "The driver will get back in the car," "The lake will dry up," etc. Histories which could be presented after the picture include phrases such as "The driver of the car went into the gas station," "The car just ran out of gas," and "The lake was dry last summer."

Let's consider the structure of some of these form-schemata. We have chosen to represent these schemata in the format of predicate calculus, in order that the predicate-argument or procedure-parameter relationships (the scope relationships, in other words) should be clear. In order to make these schemata active procedures in a computer simulation, they would have to be integrated with a pre-existing data base of lower-level schemata, such as those named as sub-schemata of these schemata. It is our intention that the procedures here described could be integrated into one of the MEMOD data bases (Norman, Rumelhart, & LNR, 1975), such as NOUNWORLD or STORYWORLD.

First, consider the form of a Description-Schema.[2]

---

[2] The use of "double curly brackets" $\left\{\right\}$ in this schema and in those below is intended to connote that only one of the elements enclosed in these brackets will appear in any given instance of the schema. Thus $\left\{\begin{matrix}a\\b\\c\end{matrix}\right\}$ means that either a, or b or c can be used to convey whatever schema this curly bracket pair occurs in. All three are expected to some extent when the schema they are part of has been activated. But no more than one of them is possible as an instantiation of the calling schema.

```
DESCRIPTION (OBJECT)
     is when
   ⎧ NOUNPHRASE (OBJECT)                                           ⎫
   ⎨ EXIST (OBJECT, LOCATIVE-PREPOSITION (OBJECT, LOCATION))       ⎬
   ⎩ POSSESS (OBJECT, QUALITY)                                     ⎭
PART-OF (OBJECT, PREVIOUS-SCENE)
          end.
```

What is the meaning of the Description-Schema? It means that a Description may be conveyed by any of three syntactic-semantic devices. The Description-Schema is "satisfied" or "activated" if any one of these three subschemata are activated. The first of these syntactic devices is simply a noun phrase whose referent is an object. (There is, in addition, a restriction placed on this object--see the last line of the Description-Schema--namely, that the object be part-of the previous scene shown the subject/reader.) The NOUNPHRASE schema has an internal structure of its own, which is not discussed here, but which would, presumably, include the full range of syntactic possibilities for noun phrases.

The second possible syntactic-semantic device for conveying a description, according to the Description-Schema, is a locative sentence, which predicates a locative relationship between the object and some location. The third device is a qualitative sentence (such as "The lake has an island" or "The car is small"). Again, the Description-Schema can be satisfied if the subschemata for either one of these devices is activated. In any case, the restriction that the OBJECT mentioned in these sentences must be part of the just-presented scene still holds.

Consider now the structure of another form-schema, the Prediction-Schema.

PREDICTION ($OBJECT_1$, [$OBJECT_2$, $OBJECT_3$,....])[3]

is when

FUTURE (Proposition ($OBJECT_1$,... [$OBJECT_2$, $OBJECT_3$,...] ...))

PART-OF ($OBJECT_n$, PREVIOUS SCENE)

end.

When the Prediction-Schema is activated, the reader expects that the phrase to be presented will be in the future tense. The FUTURE schema must, then, provide for the fact that the sentence can use either the <u>will</u> construction or the <u>be going to</u> construction to convey the future tense. The Prediction-Schema requires that at least one of the noun phrases of the sentence (or, rather, at least one of the arguments of the proposition) must have for a referent an object from the previously presented scene.

Thus far we have considered only the top-down processing effects of these form-schemata. It should be pointed out that these schemata are also open to the effects of bottom-up activation. We have discussed the fact that these schemata excite or activate their component sub-schemata when they themselves are activated (as a result of, say, the set provided by the instructions). It should also be clear, however, that the form-schemata can themselves be activated in a bottom-up, data-driven fashion, when their own subschemata happen to become activated independently. For example, if the FUTURE schema were to become activated as a result of syntactic or lexical processing on a phrase (e.g., the phrase <u>is going to</u> would ordinarily result in the activation of the

---

[3]The use of square brackets to enclose some of the parameters of a schema indicates that those parameters have optional status. This means that only one of the objects from the scene need be mentioned in the prediction, but that other objects can optionally be included.

FUTURE schema), then this alone would be enough to at least partially activate the Prediction-Schema. Mutual activation works both ways (see Levin, 1976, for a discussion).

Form-Schemata in a Broader Context. Although it is undoubtedly an instructive exercise to develop a theory of form-schemata within the restricted experimental context we have been using, we would do well to remember that real reading does not consist of a sequence of tachistoscopilly presented flashes, each one preceded by a context-setting picture. In naturalistic reading, context is not ordinarily established by preceding pictures. Natural texts are ordinarily long sequences of sentences, with only occasional graphic supplements in certain types of texts. The differences between ordinary reading and the sort of reading which subjects do in the experiment we have been discussing have several consequences for the application of the schema theory of conceptually-driven processing to ordinary reading. One of these consequences has to do with the coherence or unity which is an important aspect of any well-written lengthy text. Another consequence is related to the fact that the contextual effects which result in the activation of particular content-schemata must be ascribed not to the presentation of a picture, but rather to the reader's understanding of the preceding textual material.

Consider first the coherence or unity of most natural texts. The form-schemata which were discussed above (such as Description and Prediction) were designed to account in part for the order of the individual words of the presented phrases. In real texts, however, there is also a partially predictable ordering of the phrases and sentences of the body of the text. The intended meaning of almost any naturally-occuring text would almost certainly be grossly violated if, for example,

the sentences of the text were to be put into random order. Rumelhart (1975) has tried to account for these facts about the higher-order structure of texts by developing a special kind of form-schema to account for the episodic structure of narratives which are characterized by having primary protagonists. His "schema for stories" can be thought of as a form-schema which guides readers' expectations about the sequence of ideas in a narrative text.

There should, presumably, be other types of high-order form-schemata for guiding conceptually-driven processing in the reading of texts. For example, Rigney (1976) has suggested that textual materials be classified as one of the four following types: narrative, explanation, representation, or prescription. Accepting this classification system, the only type of text for which a high order text-processing schema has been developed is narratives (Mandler & Johnson, 1977; Rumelhart, 1975; Thorndyke, 1977). Since the processing of the other text types is probably of even greater significance for pedagogical applications, this is obviously a rich and important field for future model-building. Rigney proposed that these four kinds of information may be found separately or intermingled in one text, that the knowledge derived from each may contribute to conceptually-driven motor performance, and that different kinds of motor performance may depend upon different amounts and mixtures of this knowledge. At issue here are the effects of these different kinds of information on text-processing strategies. To examine this issue, it is necessary to characterize these four categories of information in more detail.

As we pointed out above, the interest of procedural semanticists currently is fixed on narratives. The outstanding features of narrative information: temporally-related episodes, characters, and plot, set this

kind of information apart from the other three categories. The reader of a narrative can identify with one or more characters and vicariously experience their emotions as temporally-ordered events unfold. Novels are simulations of the episodic flow of life, from which the reader can create an impression of immediacy and personal involvement. Narratives usually are written with concrete nouns about concrete episodes, with non-technical vocabularies, and the narrative styles usually are designed for easy reading. Reading narrative text is closer to the data-limited type of processing discussed by Norman and Bobrow (1975) than to resource-limited processing. That is, words are easily understood; sentence structure is easily followed by most readers. Speed and accuracy of processing are not normally limited by competition for the reader's processing resources. The presence of protagonists in the narrative, the episodic nature of the text, and the plot must facilitate conceptually-driven processing. These features, combined with high imagery-value descriptions probably facilitate retention. These characteristics of narrative also make this type of information attractive for research. However, narrative information is infrequently encountered in technical training or in the sciences, where explanatory, representational, and prescriptive information are more common.

We have just characterized the reading of some texts as data-limited processing and the reading of other, more difficult texts as resource-limited processing, using the terms introduced by Norman and Bobrow (1975). To some it may seem that we violate the spirit of these terms, since Norman and Bobrow apply the 'data-limited' designation primarily to simple 'sensory' processes, such as hearing a signal in noise. However, Norman and Bobrow make it clear that the terms

resource-and data-limited are not absolute, but apply only to processes <u>within a particular range of resource allocation</u>. Thus, if we were to consider situations in which people are simultaneously doing other resource-demanding tasks, such as shadowing of a tape-recorded message, as well as reading the text, then we would expect all types of text processing, including narrative reading, to appear resource limited. What we are concerned with here, however, is normal reading, in which subjects are not simultaneously trying to carry out other complex cognitive tasks. (We mention in passing that some people seem to be capable of knitting while reading novels but not while reading technical materials.) In normal reading, well-practiced adult readers can be said to behave in a data-limited fashion while processing most narrative texts. (There are exceptions, perhaps, for the work of certain authors, such as James Joyce, but it is not certain that such texts can be simply classified as narratives.) Performance, particularly if measured by self-ratings of understanding or by grasp of basic plot structure is likely to be uniformly high for such texts.[4] Measures of performance similar to those mentioned above for narratives would reveal much poorer results for the same readers with more technical materials, if, say, the same amount of reading time per word were alloted to the subjects.

Explanation, a form of information encountered in all science, is characterized by lexical items with highly specialized referents, often abstract concepts, which are related by causality more often than

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[4] Boswell, the biographer of Samuel Johnson, provides an extreme example of data-limited processing in reading. He claims to have found Johnson weeping because he could not turn the pages of a book as quickly as he could read them. (Boswell seems to feel this was a tribute to Johnson's amazing mental faculties, but it seems possible to us that it was intended by Johnson more as a comment on the dearth of content in his reading matter.)

by time to other abstract concepts. Rather than a time-based flow of high imagery episodes, there is a causally-based sequence of description based on abstractions. The vocabularies used in explanations contain technical terms that may be unfamiliar to the reader, and the expository style often is forbidding.

Processing for comprehension of lexical items in explanatory information interacts with processing for higher semantic structure. The reader has to work harder to translate the text into a paraphrase equivalent that he feels he comprehends. Translating technical terms must engage a different set of schemata than reading a narrative, if the reader decides to try to infer the definition of the term from the context, or if he decides to look in another source for its definition. Either of these activities becomes a major feature of the processing strategy. Some relationships among explanatory concepts tend to be confusing to keep track of and to remember. Paired opposites are examples; positive-negative, 0-1, high-low, minority carriers and majority carriers, forward biased-reverse biased. Verbal explanation in which objects or events are changing state from one opposite to another as a consequence of other objects or events changing state from one opposite to another often are very confusing on a first reading.

Processing explanatory information can be more resource-limited than data-limited. Processing is more likely to be pushed into a degraded mode, in which the reader does not fully understand what he is reading.

Information in the form of representation describes features of objects. Representational information tends to contain a high proportion of graphic material to supplement text. Its semantic structure

tends to be closely related to the structure of the object being described, so that in a particular technical domain, say electronic equipment and systems in the Navy, representational information can be organized in one of a few standard formats. After some experience with these, the reader can develop schemata of these structures that will facilitate subsequent processing of material in this domain. The fact that the object that is the subject of the representation usually has a well defined physical and functional structure must also facilitate conceptually-driven processing. Objects can be classified into families based on similar structures, and higer-level schemata can be learned that allow predictions based on names of objects and their structural or functional features. Furthermore, many of the schemata for one object would be highly useful for processing representational information about another similar object, at the conceptually-driven level. Graphic material in representational information would influence processing strategies. Good pictorial information can quickly convey physical and functional structure. Block diagrams are presumably easily converted to high-level schemata. Examination of block diagrams probably should occur early in a text-processing stragegy.

Like explanation, representation is likely to involve abstract concepts represented by lexical items unfamiliar to the reader, and thus text-processing is likely to be forced toward the resource-limited mode. However, representation, involving as it does description of concrete objects, allows the use of content-schemata developed from experiencing those objects, which should facilitate conceptually-driven processing, as, for example, for relating functional to physical structure of an electronic device.

Prescriptive information is concerned with procedures. It describes how to do something. We use a broad definition, to include general rules for doing something as well as step-by-step instructions. We will consider general rules of this type, once learned, as sources of top-level schemata, which can direct behavior in certain circumstances. We adopt this viewpoint for the time-being, at least, although we recognize that Scandura (1977) makes a different use of "rules" in his theory of structured learning.

The structure of prescriptive information is heavily time-based. Human performance is composed of strings of relatively simple actions organized by goal structures (Rigney and Towne, 1969; Rigney, Towne, King and Langston, 1972). Textual information of this type may describe goal structures, or it may describe physical actions, or it may be a mixture. It, too, is often supplemented by pictures and diagrams, and it may contain, as for statistical algorithms, worked out examples. It is often the case that, in following prescriptions, it is difficult to tell when an intermediate goal has been attained, or if some error has prevented its attainment. Man/machine interfaces upon which serial tasks are performed often do not provide this kind of detailed feedback. For example, without cross-checks, an error in a long statistical computation may not be detected immediately.

Prescriptive information often assumes that the reader already possesses world knowledge that he can use to complete the prescription. This assumption usually applies to details of procedures. Brown (1976) has pointed out examples of implied procedures in prescriptions used to teach mathematics.

The goal structures for prescriptions can be causally as well

as sequentially related. If the goal is to operate a device, say a radar repeater, the power must be turned on and other controls must be set to put the repeater in the correct mode. If the top-goal is to compute the standard deviation from a set of observations, certain intermediate results must be computed first. Different patterns of sequence relationships within goal structures were described in Rigney et. al., (1972) for serial tasks to be performed on man/machine interfaces. Similar patterns no doubt exist in other goal structures in prescriptions. Both the sequential and the causal structures of prescriptions should aid conceptually-driven processing of prescriptive text. Procedural schemata from prior experience with other prescriptions of a similar kind would be used. Resource limitations for processing prescriptive text could relate to lack of understanding of technical terminology, or from gaps in the instructions, i.e., implicit procedures. The reader might not detect these gaps until he tried to use the instructions to do something. Since prescriptions could vary from lists of general rules to explicit step-by-step instructions, processing them could be either primarily resource-limited or primarily data-limited.

In summary, we have attempted to distinguish among four types of textual information; narrative, explanation, representation, and prescription, on the basis of features that would influence conceptually-driven processing. These different kinds of information contain different features that impose processing loads at different structural levels of the text and that drive processing either toward being data-limited or being resource-limited. Processing simple narratives would tend to be data-limited. That is, all levels of the text are easily understood, so processing can proceed at top speed to fill in slots of

existing schematic structures. The other three kinds of information may contain technical terms at the lexical level whose meaning is unknown to the reader. Learning the meaning of these terms by looking them up outside the text takes time from processing the text. If the meaning cannot be found, comprehension of the text will be degraded. The other three categories of text also often are incomplete representations, explanations, or prescriptions, because the author assumed the reader could complete them by inference or already possessed the knowledge or procedures the author left out. If these resources are not possessed by the reader, text-processing will be resource-limited. Strategies are likely to be different for data-limited than for resource-limited processing. The latter is likely to be more heavily data-driven, to be slower, and to be operating more often in a degraded mode.

Actually, it is probably not the case that natural texts can, in general, be classified simply as an example of one or another of the above four text types. Most natural texts of more than a couple of pages probably consist of a sequence or mixture of these text types. For example, an electronics trouble-shooting manual might be expected to include explanations of the functions of certain circuits, representations of the layout of the circuits, prescriptions for actual troubleshooting (e.g., "Always disconnect the power while removing the case of this instrument."), and possibly even narratives (e.g., "Once there was a young repairman named Frank, who thought he would save time by not disconnecting the power before removing the case of the XG-34..."). Of course, it is not always true that natural texts are a mixture of these text types. Narrative texts, in particular, may sometimes be very extensive, even of book length, without ever being interrupted with prescriptions or explanations. Nonetheless, pedagogical materials in particular are probably

characterized by mixtures of the four text types. Schemata for the three text types which have not yet been modeled need to be developed.

Content-Schemata

Within the simple and not-wholly-natural context of the tachistoscopic experiment we have been using to discuss conceptually-driven schemata, content schemata are fairly straightforward. Content-schemata can vary in complexity, just as form-schemata can. The simplest sort of content-schemata are those which are closely bound to single lexical items (words). In the experimental paradigm, these are the concept schemata which are responsible for the subject's recognition that one object in a picture is a car, another is a lake, and so on. Once these concepts have been activated (the idea of a car or the idea of a lake), then the names for these concepts, "car" or "lake," are also activated, and are thus, to some extent, expected in the subsequent tachistoscopically presented phrase.

We will present as examples of the class of lexical-level content-schemata two instances, one for the concept lake and one for the concept Volkswagen. Consider first the schemata for Volkswagens.

VOLKSWAGEN (x)
    is when
NAME (x, "Volkswagen")
CLASS (x, CAR)
CLASS (x, VEHICLE)
CLASS (x, OBJECT)
SHAPE (x, ...)
SIZE (x, ...)
COLOR (x, variable)
    etc.

Here the visual properties of Volkswagens are specified

DRIVE (PERSON, x)

SOMETIMES (NEED (x, GAS)) — Here the functional properties of Volkswagen are specified

etc.

end.

Presumably, it is the visual properties of Volkswagens, as specified by subjects' Volkswagen-schemata, which enable subjects to recognize the appropriate portion of the Figure as a Volkswagen. (It is not our concern here to specify how this is accomplished; see Winston, 1975 for some recent work on a frames or schemata approach to visual recognition problems.) Once these visual information subschemata have been activated, as a result of visual processing of the picture, they cause the schema for Volkswagens to become activated. This activation results in certain expectations with respect to some of the lexical items in the subsequently presented phrase. The only direct lexical activation as a result of the Volkswagen-Schema is "Volkswagen." (Perhaps we should have also included in the schema the alternate name "Bug.") In fact, however, the activation of the Volkswagen-Schema not only causes the word "Volkswagen" to be expected, but also, indirectly, other lexical items. It does this by causing activation of other lexical-level content schemata, which, of course also have their own names. For example, the schema VOLKSWAGEN activates the schema CAR, which has the name "car." Therefore, "car" is another expected word in the phrase which the subject will see after the presentation of the picture.

In some of the example sentences and phrases mentioned earlier, reference was sometimes made to objects which were not pictured in the figure shown to the subjects. For example, "the driver" can be referred to in a post-picture phrase. It is possible that such references are

more difficult for subjects to perceive in a tachistoscopically presented phrase than references to objects which were seen. However, it seems likely that they are easier to perceive than are references to irrelevant objects, such as "the popcorn." One possible answer to how this mechanism of <u>relevance</u> is achieved is to be found in the content-schemata. Because the Volkswagen-Schema includes a subschema which has a PERSON who DRIVES the car, there is some expectation for a reference to this person, although this may be only weakly activated.

It should be remembered that the nature of the "expectations" we have been discussing for these particular lexical items is necessarily somewhat weak. There are a large number of possible lexical items, based on the schemata activated by the depictions of objects in the picture presented to the subjects, so not a great deal of activation can be alloted to any one lexical "hypothesis."

Another activated lexical-level content-schema is the Lake-Schema, which is responsible for the subject's expectation that the word "lake" may appear in the tachistoscopically presented phrase. Here is the schema.

LAKE (x)
is when
NAME (x, "lake")
CLASS (x, BODY-OF-WATER)
CLASS (x, LANDSCAPE-FEATURE)
CLASS (x, OBJECT)
SHAPE (x, irregular & variable)
SIZE (x, large & variable)
COLOR (x, BLUE, GREEN, GRAY)

POSSIBLE (EXIST (ISLAND, in x))

etc.

POSSIBLE (SAIL (BOAT, on x))

POSSIBLE (DRY-UP (x))

etc.

end.

Content-schemata can, of course, be activated by other means than the perception of possible referents of these schemata in a picture. In normal reading of a sentence like "John asked his mother if he could sail the boat," the lexical-level content-schema SAIL will ordinarily begin to be activated slightly before the schema BOAT (simply because reading is normally a left-to-right process). To some extent, the prior activation of SAIL will facilitate the activation of BOAT, because the schema BOAT is a possible component of the schema SAIL. If the sentence were "John asked his mother to pass the gravy boat," the lexical-level content-schema GRAVY would not activate the schema BOAT, although it would presumably activate the schema for GRAVY-DISH, which would, in turn, result in an expectation for the lexical item "boat," a possible name for a gravy container. Anderson & Ortony (1975) and Anderson, Pichert, Goetz, Schallert, Stevens & Trollip (1976) have demonstrated that contexts have the property of selecting specific interpretations for the lexical items that appear in them. They show further that it is these interpretations (or instantiations of the relevant schemata) which seem to be remembered, rather than the lexical items themselves.

More Comprehensive Content-Schemata. People reading texts undoubtedly have other, more complex or more integrative, content-schemata at work when they are reading texts. Text understanding consists of

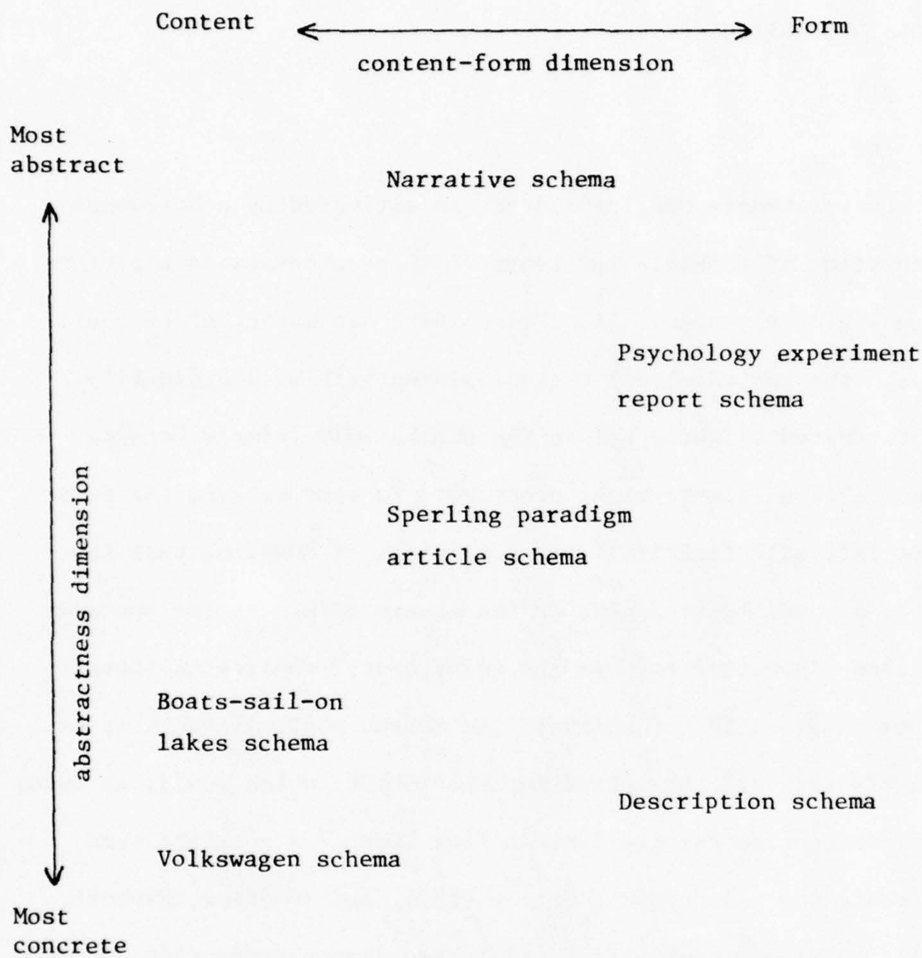

Figure 4

Examples of different schemata

more than stringing together lexical-level concepts. Some simple examples of supra-lexical schemata are included in the above schema for the concept lake. For example, the "POSSIBLE (SAIL (BOAT, on x))" subschema conveys the notion that boats can sail on lakes. There must be a large number of simple schemata like this, which reflect people's knowledge about possible relationships between objects in the world. Such schemata can be activated in reading in a number of different ways. The perception of a lexical item such as "boat" or "lake" whose concept-schema participates in such a relational schema (like "POSSIBLE (SAIL (BOAT, on LAKE))") results in the activation of the relational schema, to some extent.

Many more abstract content-schemata are possible. For example a psychologist who is familiar with the Sperling Paradigm of short-term memory experiments will experience an activation of his or her Sperling-Paradigm-Article-Schema when reading a report of such an experiment. At the level of greatest abstractness, the distinctions between form and content-schemata become less absolute. The Sperling-Paradigm-Article-Schema just mentioned surely has form characteristics as well as content characteristics (e.g., the activation of such a schema should mean expectations for a certain format -- Introduction section, followed by Methodology, followed by Results, etc.). The extremely abstract, comprehensive schemata proposed for narratives (Rumelhart, 1975; Thorndyke, 1977; Mandler & Johnson, 1977) have content aspects as well as form.

Figure 4 gives some examples of different types of schemata varying along two dimensions: abstractness and the content-form dimension.

Experimental Evidence for the Effects of Content-Schemata in Reading

What kind of experimental or observational evidence can be cited in support for the kind of content-schemata we have just suggested? One type of experimental evidence, which supports the existence of the sort of context effects predicted by the lexical-level content-schemata, is provided by Swinney and Hakes (1976). Earlier research (Foss, 1970; Foss and Jenkins, 1973) showed that the presence of a lexical ambiguity in a neutral sentence resulted in a momentary increase in processing complexity, as measured by reaction time in a phoneme monitoring task. Swinney and Hakes showed that "at least some types of prior disambiguating contexts can eliminate the processing load effect typically obtained following an ambiguity." (p. 688). Because one meaning for a potentially ambiguous word was activated by the context, apparently only that meaning of the word was activated when it was read. This seems to support the claim inherent in the model for lexical-level content-schemata that access to a concept for a lexical item results in access to concepts for related words.

There is also evidence for effects due to content-schemata with larger scope than lexical-level schemata. One of the most compelling "demonstration experiments" that comes to mind is a group of reading experiments done by Bransford and Johnson (1973) and some of their co-workers. In one experiment, for example, all subjects were required to read a brief passage (about 100 words). Half of the subjects were given the passage with one title; half saw it with a different title. The first title was "A Space Trip to an Inhabited Planet." The second was "Watching a Peace March from the 40th Floor." This was the text which followed the title:

> "The view was breathtaking. From the window one could see the crowd below. Everything looked extremely small from such a distance, but the colorful costumes could still be seen. Everyone seemed to be moving in one direction in an orderly fashion and there seemed to be little children as well as adults. The landing was gentle, and luckily the atmosphere was such that no special suits had to be worn. At first there was a great deal of activity. Later, when the speeches started, the crowd quieted down. The man with the television camera took many shots of the setting and the crowd. Everyone was very friendly and seemed to be glad when the music started." (Bransford & Johnson, 1973, p.412)

As can be seen, the text makes quite good sense when understood from the viewpoint of either title.[5] But what does it mean to "make good sense from the viewpoint of either title"? What does this mean in terms of the processing the reader is doing as he reads the text? From the point of view provided by the theory of content-schemata the title has the effects of activating different content-schemata, one having to do with peace marches the other with spaceships or science-fiction. These schemata are mid-level content schemata. They have much larger scope than simple lexical-level schemata, but they do not have the depth and complexity (or many of the form characteristics) that larger schemata such as an episode-schema might have.

According to our theory, when one of these schemata is activated, it guides processing of the text. Many of the sentences in the text are evidently ambiguous. Yet the feeling one has in reading the text, after first having read one of the titles, is not one of ambiguity at all. Because one has formed a conceptual "set" which guides processing,

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[5] In fact the 5th sentence, "the landing was gentle and luckily the atmosphere was such that no special suits had to be worn," does not make very good sense from the viewpoint of a peach march. This sentence's significance in the experiment is discussed below.

each of the concepts introduced by the sentences already has a "slot" to fit into in a preexisting mental structure, the activated Peace-March-Schema or Spaceship-Schema.

What could be the format of such mid-level content-schemata in the schema framework we have been using? Here are possible structures for a Peace-March-Schema and a Spaceship-Schema.[6]

PEACE-MARCH

is when

LARGE (GATHERING (PEOPLE))

ORDERLY (MOVE (GATHERING (PEOPLE), down STREETS))

INTEND (PEOPLE, DEMONSTRATE (PEOPLE FAVOR (PEOPLE, PEACE), to POLITICIANS))

POSSIBLE (SING (PEOPLE))

POSSIBLE (SPEAK (LEADER, to PEOPLE))

POSSIBLE (NEWS-COVER (MEDIA, _i_))[7]

end.

SPACESHIP-LANDING

is when

LAND (SPACESHIPS, on ALIEN-PLANET)

POSSIBLE (EXIST (ALIEN-CREATURES, on ALIEN-PLANET))

POSSIBLE (SIMILAR (ALIEN-CREATURES, HUMANS))

POSSIBLE (BREATHABLE (ALIEN-ATMOSPHERE))

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[6]It should be remembered that schemata such as those following are designed to convey not the authors' concepts for the particular ideas, but rather the concepts of some mythical "average man." There have been previous attempts to describe some important mid-level content schemata by psychologists. Heider's (1958) attempt to formulate a "naive psychology" is one example of this. The present work, however, has the benefit of a more explicit model framework (namely, procedural semantics) than did Heider's.

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[7]The symbol _i_ is used to refer to the activation of the calling schema itself, in this case, the activated Peace-March-Schema.

POSSIBLE (FRIENDLY (ALIEN-CREATURES, to HUMANS))

end.

What evidence is there that the two different titles resulted in different processing of the text, aside from the introspective reports of readers that they have different mental experiences when reading the same text with different titles? Recall the sentence mentioned in Footnote 5, "The landing was gentle and luckily the atmosphere was such that no special suits had to be worn." The concepts introduced by this sentence do not seem to fit naturally into a Peace-March-Schema, although they work well in a Spaceship-Landing-Schema. In a post-treatment test of memory for the text passage, those subjects who read the passage under the "peace march" title had significantly poorer memory for this sentence than did those subjects who read the passage under the "spaceship" title.[8] In other work (Barclay, 1973; Bransford, Barclay & Franks, 1972; Bransford & Franks, 1971; Johnson, Bransford, Nyberg, & Cleary, 1972) Bransford and his associates demonstrated that memory and depth of understanding are closely related. We may consider it likely that subjects who read the passage under the "parade" title did not have as complete an <u>understanding</u> of the anomalous sentence and its significance in the framework of the narrative as did the subjects in the other group. From the viewpoint of our theory of reading, the reason for this difference is that the activations of the Peace-March-Schema did not make any conceptually-driven processing contribution to the understanding of this

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[8]"After hearing the passage, Ss were asked to recall it. Most sentences were recalled well except for the one about "the landing." There was extremely low recall for this sentence, and Ss noted that there was one sentence (i.e., about a landing) that they could not understand. Even when presented with a "cue outline" (e.g., Luckily the landing ________ and the atmosphere ________.), Ss exhibited very low ability to remember what the sentence was about." --Bransford & McCarrell, 1974, p.207.

particular sentence during reading. For those subjects who experienced an activation of the Spaceship-Landing-Schema, however, there was an important conceptually-driven contribution to the understanding of this sentence.

Schallert's (1976) work can be viewed as a replication of the underlying findings of Bransford & Johnson (1973), with more nearly precise control of the structure of the texts. Subjects read paragraphs which were specifically constructed to be ambiguous, each having two coherent and distinct semantic readings. The two titles prepared for each text determined which reading was appropriate. The results showed that when subjects processed a text for meaning, the nature of their memories for the text were partially determined by the preceding title.

What possible significance for application to adult reading strategies do the results of Bransford and Johnson's experiment have, when viewed from the perspective of our theory? They suggest that maximum understanding, memory, and efficiency in processing obtain when readers have experienced prior activation of <u>the appropriate</u> mid-level content-schema. One prosaic application of this suggestion is that texts should be written with <u>appropriate headings</u>, that is, those which will cause the activation of schemata which have slots for the major concepts presented in the portion of text following that heading. Another possible application would be to train adult readers to make more effective use of headings. For example, if a reader thought briefly about each heading before actually reading a text, he might begin the reading task with a very good idea of the meaning of the text, due to the activation of a number of content-schemata of varying scopes. This seems to be an important aspect of a number of

reading improvement courses, such as the Evelyn Wood Reading Dynamics program. This kind of application is discussed in detail below. Still another way in which readers can be brought to experience the activations of facilitative content-schemata is for them to read some simple, short, prepared summary of the text first. Educational psychologists have explored the use of such summaries and related preparatory materials, which they call "advance organizers." For recent reviews of this literature, see Faw & Waller (1976) and Hartley & Davies (1976). It has been noted that one of the greatest problems with this area of educational research is the lack of a cohesive theoretical framework for characterizing or comparing particular advance organizers. It may be that the theory for content-schemata we have described, when coupled with a framework for producing summaries such as that proposed in Rumelhart (1975), could provide such a framework for analyzing advance organizers.

Application to Adult Reading Strategies

Rumelhart does not deal with our major interest here, intentional control over the reading processor. He has described an automatic, probabilistic processor. It seems clear to us that, superimposed on this, there must be a control structure, an executive level, that can assign different kinds of processing tasks to the reading processor. Most text contains a variety of different kinds of information; it is a kind of information fruit cake. The resources of the reading processor can be deployed to satisfy a variety of different kinds of goals associated with surface structure and deep structure, and to satisfy one goal there may be more than one processing strategy. For example, if we are reading for meaning, we can continue to pick up information on successive

passes (many experimental studies of reading allow only one pass). We can set our reading processor for different subgoals on each pass, or for a maximum comprehension on each pass. We can skip around, not following the serial topography, or we can follow it. We can review our retention of what we just read, or not, between passes. We can regulate the amount of processing capacity we expend, from low-concentration skimming to high-concentration reading. We can read with the intention to remember, or with some short-term goal in mind that does not require long-term retention (e.g., looking up a telephone number). The common denominator of all text processing strategies seems to be limited input capacity. It is not an accident that the information in texts is packed in serial strings.

Supposing that the theories outlined above offer a reasonable way for us to try to understand some of the effects of conceptually-driven processing in reading. Do they have any applicability to adult reading strategies? We think that they do, and that, to some extent, they help to explain the effectiveness of the commercial reading effectiveness courses approach, discussed below under Extractive-Multi-Pass Strategies.

Text-Processing Strategies

We will group these as single-pass strategies and multi-pass strategies. In what follows, we attempt to delineate basic strategies for understanding text. That is, we assume that the reader has the task of understanding all or a selected part of a text passage. We will leave for subsequent consideration the influences of other orienting tasks, noting in passing that the literature contains many examples of the effects of different orienting tasks on word, sentence, and text processing. One of the most striking is the demonstration by Aaronson

and Scarborough (1976) that subjects who were told they would have to recall sentences word-for-word used different word-by-word reading-times and patterns than subjects instructed simply to comprehend the sentences. During reading, recall subjects spent an average of 181 msec more per word than comprehension subjects, and their phrase structure processing patterns were markedly different. We also recognize that text in textbooks often is supplemented by review questions, exercises, or problems; and that the reader can choose to use or be taught to use rehearsal, or mental imagery, or other learning strategies. For a preliminary discussion of these issues, see Rigney (1976).

Single-Pass Strategies. It might be possible for a reader to start at the beginning of a text, with the first word, and read it word-by-word straight through to the end, without looking ahead or looking back. The reader would attempt to comprehend the text on one trip through. However, eye-movement studies indicate that strict, word-by-word processing seldom occurs. Readers may look back at parts of sentences, or look ahead, or cross sentence and paragraph boundaries in the search for meaning. For experimental purposes, it may be necessary to force an approximation of strict single-pass processing. A necessary condition is segmented presentation of the text, word-by-word, sentence-by-sentence, or frame-by-frame, to prevent non-sequential visual scanning strategies. Auditory presentation often is used, although this adds the requirement for phonemic processing, and drops the requirement for graphemic processing. Strict single-pass processing can be forced, as in Thorndyke's study, by paced presentation, e.g., one line at a time for 5 seconds. Even here, it seems likely that students might scan back and forth on the line during the 5 seconds. Less strict single-pass

strategies are allowed by sequential programmed instruction frames which may contain more visible information, and may require additional processing in a frame. The student processes the module, answers a question about it, and goes on if correct or reprocesses it if not. The frame could be shown briefly and then removed.

There seem to be several things wrong with single-pass processing strategies. For example, they reduce the scope of the input for top-down processing, using the topography of the page, and skipping about across sentence and paragraph boundaries to pick up clues to higher-level structure. Clues to this structure must be accumulated word-by-word and sentence-by-sentence, before it can be predicted from prior experience with similar material. This could limit the contributions of conceptually-driven processing.

Some kinds of single-pass strategies may be effective for processing some kinds of text. In conceptually dense, technical material, there can be many technical terms that are not explained in the text. The student may have to search for explanations of these terms and re-write the sentences, one by one, substituting the explanations, before he can comprehend the passage made up of the sentences. This seems to be a matter of translating the data into equivalent, analogical or metaphorical forms, that can be used by conceptually-driven processing. This is one way of achieving understanding of conceptually dense text.

Multi-Pass Strategies. Single-pass strategies discussed above are based on the idea that all the information in the text can be extracted on one trip through. It is the acquisition of ideas, rather than the acquisition of words that distinguishes single-pass from multiple-pass strategies. The basis for multi-pass strategies is that

several passes could be more effective than a single-pass. Putting text on pages and ordering pages in sequence allows the reader to select any part of the text he pleases to process next. He can cross over sentence, line, paragraph, and page boundaries any time he chooses. He can go back and reread a phrase or sentence he does not understand, or look ahead to get some idea of higher levels of organization, or skip over material he already understands or that is not relevant to his goal. He can selectively process to satisfy some non-semantic objective, ignoring the information in the text. How should he use this power and flexibility of his text processor?

It seems to us that these strategies should utilize the power of conceptually-driven processing in the top-down, bottom-up model. Heretofore, the implications of conceptually-driven processing in text comprehension seem to have been overlooked. Yet, it is clear that it is of overwhelming importance. Most of the time, when we are reading, we are acquiring new information from data that consists of utterly familiar patterns of letters in words, words in sentences, and sentences in paragraphs. From whence comes the new information?

It may be useful to distinguish among the different kinds of multi-pass strategies on the basis of how the text processor is used in each pass. Tentatively, we identify exhaustive, extractive, and selective types.

Exhaustive Multi-Pass Strategies. The exhaustive multi-pass strategy concentrates on full comprehension on each pass. We all have had the experience of reading a passage, say a chapter in a textbook, for a second or third time and each time realizing that we are acquiring more information. The exhaustive multi-pass strategy probably is fairly

commonly used by students. It is simple to apply. The reader finds a quiet environment, sits down with the text, and reads it through with as much concentration as possible, and then reads it again with deep concentration, and so on. Management of intervals between readings is important. How long should they be? What should go on in these intervals? Evidence in the literature is equivocal, although the reader probably should not read similar material during the interval, and the interval probably should not be too long. The interval could be used for a review of what was read. This will reveal irregularities in recall. Recall is likely to be good for top-level structure, not so good for details, at least for narrative information (Thorndyke, 1977; Mandler & Johnson, 1977). Review might uncover gaps in knowledge that otherwise would not be remembered from the first pass, but the review itself is likely to be selective. Whether review is done or not done, the next reading is likely to be different than the first. It will be more selective and less comprehensive, concentrating on parts of the text remembered to be difficult, skimming parts remembered to be of little importance, or already known. What seems to happen as a consequence of top-down, bottom-up interactions during the preceding pass is that confusion and some anxiety will be generated over passages that were not well understood. These feelings will motivate the reader to direct his text processor to concentrate on these confusing passages the next time. There is a tendency, then, for the exhaustive multi-pass strategy to be conceptually-driven toward the extractive multi-pass strategy on successive passes.

Extractive Multi-Pass Strategies. For non-trival passages, say a chapter in a textbook, one reading will not suffice to store all the information in the chapter in LTM, or to make all of it retrievable

from LTM. If interactions between top-down and bottom-up processing tend to make successive passes extractive, why not teach extractive multi-pass strategies? The student might be taught to look for overall structure, for terms he does not know, for summarizing sentences, for style of exposition, for different kinds of processing tasks, etc. The assumption is that relatively quick, extractive passes might accumulate contextual information that would be extremely useful for the top-down part of the text processor to use in guiding processing. If the context could be established early in LTM, could the acquisition of detailed information then proceed on an extractive basis? Multi-pass extractive processing seems to work well for reading the journals. Studies in Cognitive Psychology, Memory and Cognition, or any other scientific journal have a standard format dictated by the editorial policy. One multi-pass extractive processing strategy used to understand articles in these journals could be:

1. Read the title and summary. Do these describe what the experiment is about? If not, read a few sentences of the introduction for additional clues.

2. Look for tables or figures that summarize results and give labels of main variables. Try to get some idea of what happened.

3. Read the final discussion or summary. These give more clues to what the author thought he was doing.

4. Read part or all of the methods and procedures section to get some idea of the episodic structure of the experimental design.

5. Look for answers to unanswered questions or passages that will reduce confusion.

6. Mentally review your understanding of what was done, found, and concluded.

The Evelyn Wood reading dynamics approach seems to be the leading example of an extractive multi-pass strategy. Successful graduates

of the EW classes "read" texts at a much faster rate than they did before training. (We use scare quotes here only because some might object to the use of the term "read" when the reader does not actually see every word in the text. For our part, we feel that this _is_ reading if the reader gets just as complete an understanding as would be the case if every word had been read.) In addition, they usually seem to comprehend or remember more of what they read, based on multiple-choice measures of grasp-of-content developed by the EW staff. This seems like an anomalous result, since we in psychology ordinarily expect to find speed-accuracy trade-offs. Yet it is explicable, we think, if we understand some of the EW techniques in terms of the schemata theory outlined above. One of the most important rules that EW graduates are supposed to follow, particularly when they are reading technical material, is to _preview_ the material. The previewing is done in several passes. First, the reader pages through the text looking at major headings, picture captions, and diagrams. During this process, he or she is to try to _form hypotheses about the major points made by the text_. Then the reader makes a second pass through the material, this time a slower and more detailed one. Using the hypotheses formed in the first pass, the reader tries to form a number of partially independent hypotheses about the detailed points made by the text. On this pass, he or she tries to notice vocabulary items or concepts which are unfamiliar, with the intention of seeking the meaning of these items during the actual reading of the text. If the reader feels uncertain about the overall structure of the text or about the purpose of some subsection of the text, a third pass or a partial pass is also performed. Only when the major ideas are firmly fixed in the mind of the reader does he or she finally "read" the text. As a result of training in self-forced pacing of eye movements, this final

reading is done quite quickly, but it is not our interest here to deal with the nature of the speed training, but rather only the comprehension training.

The effectiveness of the EW previewing techniques can be understood in terms of the theory of form-and content-schemata discussed above. The first pass can be thought of as an attempt to activate an appropriate high-level textual schema, or, rather, a number of high-level schemata of both types (form and content). If the reader was not aware of the top-level form-schema appropriate to the text (i.e., whether the text was primarily a narrative, a prescription, a representation, or an explanation), this pass should activate the appropriate schema. In addition, some top-level content-schema should be activated by the first pass--the reader should experience an activation of his Psychology-Experiment-Report-Schema when he looks through a short text and discovers headings like "Methodology," "Results," "Discussion," and recognizable psychological terms in the title and figure captions. (This example is true, of course, only in the case of those readers who are familar with articles on experimental psychology). In those cases in which knowledge of the topic matter can be extremely specialized, an even more detailed and explicit top-level content-schema can be activated on the first pass. Thus, some psychologists might preview a certain article and experience an activation of a "Sperling-Paradigm-Article-Schema," rather than the more general "Psychology-Experiment-Report-Schema." The important notion provided by the schema-theory approach to reading is that previewing can activate schemata which might have beneficial conceptually-driven processing effects in reading.

The second pass, which is guided, to some extent, by the schema

activated by the first pass, should result in the activation of some more explicit, lower-level content-schemata. Some of these schemata will be lexical-level content-schemata, activated by the presence of particular words in the bits of text read by the previewer. The reader naturally tries to fit these activated schemata into the structure provided by the top-level schema.

During these passes through the text, the reader is building up a conceptual representation of the entire text in a sort of outline form. When the actual reading of the text begins, he or she does not _need_ to see every word, because most of what the text says is already _known_. Reading is then more a process of filling in the gaps in an established knowledge structure, rather than a process of creating an entire knowledge structure from scratch, essentially in a bottom-up, data-driven manner.

Why is it, then, that students of the EW method of reading appear to be capable of processing more information per unit time? We would prefer not to believe that EW graduates have significantly larger STM buffers or significantly faster-read-in and read-out of STM. What other options are there? Perhaps the nature of _what is stored_ in STM is different. Specifically, perhaps the EW graduate processes the text in significantly larger chunks. Because the EW grad has deliberately brought about the activation of a large number of top-level and mid-level schemata, the text can be understood in terms of these complex, integrative concepts _as it is being read_. When this works, it is not necessary for the reader to first store in memory each of the low-level, lexically-bound concepts in STM in sequence, and only then to figure out what the unifying, integrative concept is that captures all of these. Instead, the higher-level concept schema is already activated, and the lexical-

level units need only be superficially checked to ensure that they fill their expected roles in the integrative schema.

Selective Multi-Pass Stragegies. Obviously, the type of multi-pass strategy that is most effective will be strongly influenced by the objectives of the reader and by the type of text to be processed. No one ever needs to learn absolutely everything in a passage of text, from physical topography to deepest deep structure. Less exhaustive objectives are the rule. It is essential that the objectives be clearly specified since they will determine the processing strategies that could be useful.

In all text processing strategies discussed so far, the top level goal was assumed to be achievement of some reasonable level of comprehension of all the text. Of course, these strategies could be applied to a page, a chapter, a book. The segment of text has to be defined.

A more limited objective is very common, and is particularly important in relation to job performance requirements. The reader's needs for information from processing a text are established by a requirement to perform some task or function. He must find information in the text that will help him meet his requirement, and he wishes to learn only that information. He must be able to identify information he does not want to learn as well as information he needs. In such cases, it is particularly important that the learner not adopt an exhaustive reading strategy, since this is extremely inefficient when only a small part of the total information in the text is needed.

One strategy which may work well when the reader has a limited and specific objective with respect to selecting information from the

text is for the reader to begin, not by reading some portion of the text, but by <u>thinking</u> deeply about his objective before using the text. By thinking about the objective and relating it to what he already knows, the reader activates a number of content-schemata which should be relevant to his objective. These activations may include the activation of some specific lexical items for which the content-schemata are incomplete. If this is so, these lexical items can serve to initiate the first use of the index or table of contents of the text, if the text is provided with these self-directional aids. Even if the text is not so provided, the reader can begin his processing of the text by skimming, searching for instances of these poorly understood terms or semantically related terms in the text. Hopefully, an area of the text rich in such terms might contain the solution to his problem.

This type of multi-pass strategy is heavily concerned with locating appropriate information. By its continual use, the reader would be expected to learn schemata relating to text-searching strategies. In the professions, the volume of the literature often forces the use of this selective strategy, with the consequence that professionals are likely to have a good store of knowledge about <u>where</u> information about topics is located in scientific journals and books, and about <u>who</u> did the studies.

Since the selective multi-pass strategy is a valuable tool in job environments in which the reader must direct his own text-processing to achieve learning objectives that will allow him to accomplish specific performance requirements, this strategy is the subject of a more intensive treatment elsewhere.

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